The Interactive Image Tool: Adding Structure to Images

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The interactive image format and tool were developed by the Stanford University Medical Media and Information Technologies (SUMMIT) group to allow medical educators to add interactive annotations and outlines to medical cross-sections, gross dissections, and clinical images. The interactive image tool (IIT) format offers a general specification for adding structural information to images. The IIT format has been used to create rich databases of image/structure information which are employed in educational software created at SUMMIT. These databases consist of information which is re-usable in other applications as well as a standalone image database. Future extensions to the IIT format will provide a means to organize information based on the structure of that information rather than on the arbitrary or haphazard links of current hypertext and hypermedia information networks.

DEVELOPMENT OF THE INTERACTIVE IMAGE

The interactive image tool (IIT) has been under development at the Stanford University Medical Media and Information Technologies (SUMMIT) lab since early 1991. Work continues on constructing interactive images, designing the interactive image format, and developing the interactive image tool.

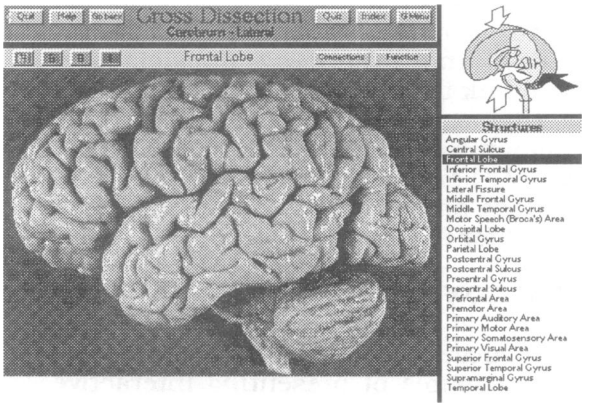
History. The concept of an *Interactive Image* arose out of initial design work on the neuroanatomy study application *BrainStorm*. There were several functions the neuroanatomy review program required, and the Interactive Image was created to satisfy them.

BrainStorm incorporated a huge collection of cross-sectional and gross dissection images of the brain. The many brain structures and pathways on each section needed labels and descriptions. The labels had to be unintrusive and removable so users could study the sections on the computer with or without informational text. The conventional textbook leader lines that label points-of-interest on images did not work in the computer program due to limited screen real-estate and inadequate labeling power (leader lines leave structure borders ambiguous).

Outlining the structures on the images made the most sense from both a programming and an anatomical perspective. Outlines saved valuable screen space and clearly marked the structure borders. Structure names could be associated with structure outlines without clumsy leader lines that obscure image detail. Once this approach was taken, how to toggle the structure label state between *visible* and *hidden* was the major hurdle to leap. The solution to this problem is the interactive image.

The interactive image satisfied all the requirements of the BrainStorm study program. The user is presented with an image and an associated text list of structures within that image (*see figure 1*). The user can click on either the image or the names in the list. Each list entry is associated with an outlined structure or structures on the image. If a list entry is selected, the associated structure outline appears on the image. Selection of another list entry causes the previous outline to disappear and the outline associated with the newly selected name to be displayed. The user can also click anywhere on the image itself. If s/he clicks on a structure, that structure is displayed and the associated structure name is hilited in the structure list. Clicking on another portion of the image outside that structure causes the previous outline to disappear and the outline of the newly clicked structure to appear. The structure list updates the hilite of the associated structure name.

Figure 1. Interactive image in the BrainStorm neuroanatomy study application. The outlined structure appears in response to a user click on the image and the associated structure name is hilited.

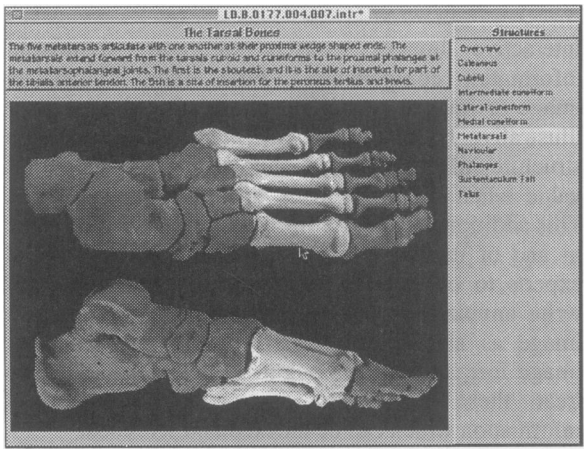


An interactive image is fundamentally a data format (see "IIT Format" below). The format contains information concerning structure within the image. The interactive image tool (IIT) allows anatomists to load an image and add structure information to it. The construction of interactive images is not a trivial task. The time necessary to author an interactive image varies based on the number of structures on the image and the amount of detail the annotations include. A moderately complex anatomical

interactive image will take an anatomist fifteen minutes to half an hour to outline completely and provide annotations for each outlined structure. The value of interactive images lies not only in the quality of the incorporated image but also in the quality of the structures and text embedded within it.

Current Work. An anatomy project, *The Anatomy Lesson*[1], currently underway at SUMMIT in conjunction with the Stanford Anatomists† and Mosby-Year Book Publishing‡ uses the interactive image tool to create a large body of anatomy interactive images for use in this anatomy study program (*see figure 2*). Several medical educators and medical students use the interactive image tool daily adding new content and revising existing material. Since interactive images are fundamentally a document format, the information sits within each interactive image document, not inside any software application. This allows parallel development of medical content by anatomy experts and avoids many common problems of versioning which arise in large, application-centric projects.

Figure 2. Interactive image in The Anatomy Lesson software. Each interactive image contains all structure and annotation information. The Anatomy Lesson accesses the information contained in each document and presents it to the user.



The information added to each image includes image references, source, comments, and carefully outlined and annotated structures. Creation of this information is a lengthy process and much effort is expended editing the images, structure outlines, and annotations. Each interactive image represents a significant *unit* of anatomical information which can serve as a valuable resource to the anatomy student. This unit is key to the concept of an interactive image. Because an individual interactive image is distinct document incorporation into many different applications can occur through access to the single units of information centered in each. The *Anatomy Lesson* uses the interactive images in a particular way, embedding them in the presentation of lessons and textbook chapters. It is easy to imagine this body of information as an anatomy reference database searchable by image name, region name, or text content. Since the structure information and annotations reside within each document and not in *The Anatomy Lesson* software for which they have been created, there is nothing preventing the use of these interactive image documents in other resources.

RE-USABLE CONTENT AND MEDIA

SUMMIT is a small technical group which helps medical faculty and students at Stanford University incorporate technology into the curriculum. To this end, SUMMIT creates tools which allow medical experts to construct content -- large "databases" of medical information -- for use in educational contexts. Much effort is involved in creating these databases, and originally each database existed as a separate entity embedded in the software for which it was created. Constructing an original database format, authoring tools, and a presentation mechanism for each new application was tantamount to re-inventing the wheel and wasted valuable time and resources. Further, the medical content was then chained to the software for which it was created and could not be re-used in whole or in-part for other purposes. A new method of software and content creation was needed that leveraged off past development efforts and allowed re-use of medical content.

A shift from a wholly *project*-centric approach to a more document or *data*-centric approach was taken in an effort to allow medical experts to create *re-usable* content and media. By taking the time initially to create generalized data formats which structure information in a useful way, we have begun to steer medical education content construction at Stanford toward a more flexible, dynamic process of resource development. This approach allows our facility to help medical educators add to a growing body of information they while work on a project of particular interest to their classes or research. Our method keeps the medical information distinct from the educational software; the software *accesses* rather than incorporates the information allowing other software packages to re-use the same information. The information is not held within one monolithic

† The Stanford Anatomists are: Dr. Lawrence Mathers, Dr. Robert Chase, John Dolph, Dr. Eric Glasgow, and Dr. John Gosling.

‡ Mosby-Year Book, Inc., 11830 Westline Industrial Drive, St. Louis, MO 63146.

database. Instead information is stored as individual components which are easy for a novice user/author to use and understand.

The interactive image document format structures information in a completely re-usable way incorporating all the interactive image data into individual documents. Much of our application development is done in Apple Computer's HyperCard™ and Allegiant's SuperCard™. We have written an XCMD¥ which, given an interactive image document file name, will read and display the information from within a SuperCard application. We can now use any interactive image in any SuperCard-based software by simply including the interactive image XCMD in the project. No major programming needs to take place within a software title and no changes whatsoever need to be made to the interactive image documents to add them to a new project. The interactive image content and media is completely self contained therefore easily usable and re-usable. Adding interactive images to an application is simply a process of copying the interactive images to a location accessible by the software and informing the application of its existence. Since the structures and annotations are stored within the interactive image itself, problems that arise from mismatching information are avoided.

IIT FORMAT

The interactive image tool (IIT) format was designed with a specific purpose in mind. Medical experts needed a tool which allowed structure information to be added to images, and that tool required a simple but comprehensive document format. The current IIT format consists of a number of data elements and pointer references to media.

The IIT format consists of image pointers, image source and other information, and a structure list with associated data. This format was designed to allow medical experts to supplement anatomy images but is extensible in interesting ways (see "Future Work" below). The format allows information about the structure of image content to be added to an image document. What form this information takes and to what uses the information is put are not defined by the format. It is our hope that the generality and utility of this format will allow others to employ interactive images in their own work.

The image pointers in the IIT format refer to images of varying bit depths. Since medical educators demand the highest possible quality of image display, standard dithering algorithms were viewed as unacceptable when 32-bit color was not available on the display platform. By incorporating images of multiple bit-depths, the IIT format accommodates content experts who require specialized image processing on images at each possible depth of display. While the current document viewers do not support three dimensional images, the IIT format lends itself quite well to the addition of this information.

Each image contains a list of structure regions and associated data. The regions are drawn using a tool similar to the Macintosh lasso tool. Text annotations are stored in the data segment of each structure element. Information including references to external media and even other interactive images (see "Future Work" below) can be stored in the data segment of each structure element allowing software packages to customize their interactive images while remaining within the scope of the IIT format.

The IIT format is a simple, extensible, and highly customizable specification for adding information to images. By embedding structure information within images in a systematic and standardized way, it is possible to build a rich database of image information that provides a much more robust and accessible resource than is possible with images alone[2].

EMBEDDED INFORMATION

Interactive images consist of two significant information components. First, they contain an image or images which are chosen because of their illustrative value. Second, interactive images contain structure information and annotations which are of value when presented with the underlying images. This additional structure information is also of value in and of itself. Great effort is taken by medical experts to outline the structures in the images and write annotations. By understanding an interactive image as significantly more than simply another image format, we have begun to design tools which treat these documents as a rich database of information which can be indexed and searched.

Creating a library of interactive images enables searches by image content. One could, for example, query an interactive image database for all the images containing the liver. Another query might consist of a search for all the images with references to the term "Glossitis." Structural information provides an avenue to image access, sorting, and retrieval that yields benefits far beyond its fundamentally illustrative and educational purpose. The added information in the IIT format does more than supplement the image with annotations; it builds

¥ XCMDs are code resources which allow programmers to add functionality to HyperCard™ and SuperCard™.

structural keywords into an image which afford accessibility and organization.

FUTURE WORK: MORE STRUCTURE

The interactive image tool (IIT) format was created to allow structural outlining and annotation of medical images. Images are embedded media in interactive image documents allowing discrete, localized construction of an information database (i.e. a database or mapping for each image). Through some simple extensions to the current IIT format, however, it will be possible to create tools that help people generate structure in any type of information stored anywhere, locally or remotely.

As described above in IIT FORMAT, the interactive image tool format consists primarily of image pointers and a list of structures and associated data. The current limitations are the types of media allowable, the types of media references allowable, and the types of recognized data. The format is easily generalized by following the concept of MIME-types[3] as employed in current tools such as World-Wide-Web browsers. The concept consists of storing data with recognizable data-type tokens which allow any application accessing the information to interpret that information based on what the application knows of that data's type. This allows a format to be built which makes no assumptions about data structure or types. It simply bundles the data with identifying tokens and leaves the interpretation to the accessing software.

We have proposed to use this method to extend the IIT format to allow for its more general and networked application. The new format would incorporate in each element of an image's structure list a triplet which completely specified that structure's information. The triplet would consist of a data name, a data type token, and a data pointer. The data name is simply a string identifying the information component. The data type token would be an agreed upon identifier signifying the type of information contained in this information component. The data pointer would point to a data block, either locally or remotely, which contained the information associated with this information component. An application accessing the particular component, then, would query the "interactive image" with a name and would receive a data pointer and type token which it could then access and use according to its specific needs.

These format extensions are a logical generalization of the current IIT format which would allow virtually any type of information to be stored and organized in an arbitrarily complex and original manner. Each object could contain a list of embedded objects, each with its defining triplet of name, type, and pointer. Information could thus be hierarchically embedded and referenced from anywhere within object structures. Objects could contain an arbitrary depth and breadth of information. This format would allow data to be organized as it was generated, as well as allow the creation of organization as a body of information grows.

IMPLICATIONS

The IIT format in its most general specification is a format which allows structural information to be embedded in media types for which this is appropriate. By embedding structure in media and incorporating references to other information, it is possible to build networks of organized media. Access to, traversal through, and searching of this database will benefit from the intuitive organization of its contents. Interconnecting information via links between its structural components adds a level of organization above the common and often arbitrary association of information through hyper-text and hyper-links. We believe the IIT format provides an important method for organizing information with structural components. We continue to develop and use the IIT format in our own work and endeavor to make this format compliant with emerging standards. Our hope is that this method of information organization will be recognized for its utility and incorporated in the ongoing process of adding order to the growing web of information available to us today.

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